DOCUMENT RESUME

ED 170 802 CS 502 503

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TITLE On the Nature of Synonyms: And This Little Piggie....
PUB DATE May 79
NOTE 34p.; Paper presented at the Annual Meeting of the Eastern Communication Association (Philadelphia, Pennsylvania, May 5-7, 1979)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Behavior Theories; Higher Education; *Language Attitudes; Language Research; *Language Usage; Language Variation; Linguistic Theory; Multidimensional Scaling; *Semantics; *Word Frequency
IDENTIFIERS *Synonyms

ABSTRACT

An experiment was conducted to investigate the nature of synonyms by using multidimensional scaling. The selected concept was "pig" and three of its synonyms--"hog," "boar," and "swine." These terms vary in their frequency of use in English, which makes it possible to explore a behaviorally based theory of meaning. Subjects were randomly assigned to one of four conditions where they performed direct pair comparisons with one of the four "pig" terms, a series of barnyard animal names, attributes, and a concept of self. The means of these four groups were entered into a multidimensional analysis. In contrast to the logical assumption that synonymous words would produce identical multidimesional spaces, the results, in fact, suggest that the four "pig" terms are not really equivalent, varying systematically in their meanings, in their use, and in their relation to positive attributes. The systematic variance in their meanings is such that each concept's distance from self on the multidimensional scale is inversely related to the frequency at which the concept is used in English. This further suggests that meaning is behaviorally governed, and that any symbol's meaning is an empirical question whose answer depends on measuring the actual users of that symbol. (Author/RL)

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ON THE NATURE OF SYNONYMS: AND THIS LITTLE PIGGIE. . .

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Presented to the Eastern Communication Association, Philadelphia,

May 4-7, 1979.

The author would like to thank David R. Brandt, James W. Dinkelacker, Joseph Woelfel, Tracy Tuffillaro, Michael Thompson and Robert Oldendorf without whom this paper would not have been possible.

CS502 503

ON THE NATURE OF SYNONYMS: AND THIS LITTLE PIGGIE...

ABSTRACT

This paper investigates the nature of synonyms through the use of multidimensional scaling (MDS). While the meaning of any word may be defined by its pattern of relationship or dissimilarity from all other lexical items, a theoretical problem arises with synonyms. Because the discrepancy of any concept and itself is zero, it logically follows that if two symbols are synonyms that their discrepancy should also be zero. But a symbol's meaning is dependent on how the word is used. Thus, while two words may refer to the same referent they may be used differently and therefore have different meanings.

An experiment was conducted to investigate the nature of synonyms. The selected concept was PIG and three of its synonyms, HOG, BOAR and SWINE. These terms vary in their frequency of use in English which made it possible to explore a behaviorally based theory of meaning. Subjects were randomly assigned to one of four conditions where they performed direct pair comparisons with one of the "pig" terms, a series of barnyard animal names, attributes and a concept of self. The means of these four groups were entered into a multidimensional analysis. If the four words were in fact synonyms, then the resulting multidimensional spaces would be identical.

The results suggest that these four terms are in fact not equivalent. Their meanings vary systematically. The concept's distance from self is inversely related to the frequency at which that concept is used in English. The results are then discussed in terms of a behaviorally based theory of meaning and finally suggestions are made for future research.

ON THE NATURE OF SYNONYMS: AND THIS LITTLE PIGGIE.....

THEORY

The formal theory behind the use of metric multidimensional scaling for the measurement of meaning and linguistic processes has been described elsewhere (Barnett, 1976; Woelfel, 1977). Rather than attempt a similarly detailed discussion here, an adumbration of the theory will be furnished which should sufficiently acquaint the reader with the theoretic foundations of this research.

The meaning of any word may be defined by its pattern of relationship or degree of dissimilarity from all other lexical items. Thus, the definition of a word may be represented by a 1 X N vector, $S_{11}, S_{12}, S_{13}, \ldots, S_{1n}$, where S_{1k} represented in the distance or dissimilarity of concept 1 and k; and the meaning of any set of words by a N X N matrix S, where any entry S_{ij} represents the distance between concepts i and j. Typically, S is averaged among a representative sample of users of a language to take into account the consensual nature of that code system (Woelfel, 1975;Barnett, 1975).

This matrix has certain mathematical properties which make it amenable to multidimensional scaling. It is a square symmetrical matrix, whose diagonal elements are zero (The dissimilarity of concept and itself equals zero by definition.) and off diagonal elements may be any positive real number. This final property makes the precise measurement of meaning possible.

A theoretical problem arises when dealing with synonyms, i.e., words with equivalent meaning.[1] Because the discrepancy of any concept and itself is zero, it logically follows that if two symbols are synonyms, they refer to the identical referent, that their discrepancy should also be zero (Ogden & Richards, 1946). In terms of word-substitution, if two words are semantically identical,

then the latter can replace the former without any alteration in the interrelationship among the symbols (matrix S). If they are not synonyms, the words are semantically different, then the first symbol cannot be replaced by the second without altering the structure of the relations (Osgood et al., 1957). The greater the dissimilarity between the terms, the greater the interrelationship among the terms will be altered.

Thus, it is expected that differences among semantic structures generated with synonyms should be zero. That is, S_i should be equivalent to S_j where, matrix S_i is the semantic structured generated with concept i, and S_j, the semantic structure generated with concept j. Concepts i and j are considered to be synonyms. This suggests hypothesis one:

H_1: The semantic structures, S_i and S_j, will be significantly different.

Hypothesis one is couched in terms such that the null hypothesis of no difference is expected. However, in terms which will allow for falsification, the theoretical hypothesis is expected to be rejected in favor of the null.

Wittgenstein (1953) has pointed out, meaning is dependent on how a word is used. Also, empirical investigations using MDS have shown that one's behavior effects the structure of scaled concepts, such that the more frequently one performs a behavior the closer that concept is to a concept of self. (Barnett, et al., 1974; 1976; Marlier, 1975; Barnett & McPhail, 1979). Linguistically, this suggests that the more frequently users of a language speak or write a word the closer that lexical item will be to a concept of self. Additionally, synonomous symbols may be used selectively with different domains such that one word is used in one semantic domain and its synonym exclusively in another. Yet, they refer to the same referent. Thus, while two words may be considered synonyms, i.e., refering to the same referent, they may in fact have different

meanings and a different semantic structure depending on their use.

This discussion suggests the second hypothesis:

> H_2: The semantic structures generated by synonyms will be systematically distorted from equivalence such that the synonym that is used more frequently will be significantly closer to a concept of self than its synonym which is used less frequently.

In order to empirically assess the preceding hypotheses, the following study was conducted.

METHODS

The semantic structure of an individual may be measured through the use of metric multidimensional scaling--M.D.S. (Barnett, 1976). The method takes a matrix of dissimilarities (or distances) such as matrix S and converts the data to a series of loadings on a limited number of dimensions. Mathematically, the process is analogous to converting a matrix of city to city mileages to a graphic representation such as a map. In that special case an N x N matrix of cities (N= the number of cities) would be reduced to a two dimensional configuration with little loss of information.

Barnett (1972) and Danes and Woelfel (1975) report reliability coefficients for the method of .85-.90 with as few as 50 cases and discuss ways of increasing the overtime reliability by the number of selection of concepts. Gordon (1976) reports reliabilities ranging from .933 to .988 with approximately 100 subjects in 9 different conditions. The predictive validity of time series metric M.D.S. has been demonstrated by Marlier (1974) in a test of social judgment theory, and by Barnett, et al., (1976) who demonstrated that the outcome of a political campaign could be accurately predicted with this method.

M.D.S. has been used extensively to study human information processing (Schroder, et al., 1967; Rips, et al., 1973; Rumelhart & Abrahamson, 1973) and

to measure semantic structure (Miller, 1969; Henley, 1969; Szalzy & Bryson, 1974, Barnett, 1977a, 1977b).

Hypotheses Operationalized

Theoretical hypothesis one may be operationalized as follows:

> H_1: The multidimensional spaces S_i and S_j will be significantly different.

It may be tested in the following manner. Generate two or more multidimensional spaces from a series of identical concepts with the exception of a single concept--the synonym. It would vary across conditions (S_i and S_j). Next, through a series of translations and rotations, minimize the degree of departure from congruence among the spaces. Then, through the use of t-tests, using the concepts as the unit of analysis, determine if the differences among the spaces differ significantly from zero.[2] When a number of spaces need to be compared, a more parsimonious solution is necessary. A more elegant way to test for significance would be to use the spaces as the unit of analysis. Once each space has been rotated to congruence with each other space, there are N(N-1) values. They are expected to be zero. Then the test for significance will be if the mean of this set of values differ significantly from zero.

> H_2: The multidimensional spaces generated by synonyms will be systematically distorted from equivalence (congruence) such that the synonym that is used more frequently will be significantly closer to a concept of self than its synonym which is used less frequently.

Hypothesis two may be tested as follows. One criterion for the selection of synonyms to be scaled should be their variance in frequency of occurrence in English. This may be determined by consulting any of the standard references on word frequency (Thorndike & Lorge, 1944; Carroll et al., 1971). Additionally, some concept of self, such as "me" or "myself" should be scaled. Then use the

mean pair-wise distance estimate between each of the synonym and the self-concept and the variance of the individual estimates to test for significant differences in the predicted direction. The symbol which is used in greater frequency should be closer to the self concept. A simple t-test may be used to test for significance between individual conditions. However, to test overall order among a number of conditions for significance linear trend analysis (Hays, 1973: 691-694) should be used. Linear trend analysis operates in the same manner as any comparison among means. However, since analysis of variance in the linear case agrees exactly with linear regression, the latter method may be used. The significance test will be performed on the correlation between the predicted rank order and the distances between the synonyms and the self. This test may also be performed with the actual frequencies of occurance and the distance estimates.

Instrumentation

The instrument used to test the above hypotheses was composed of 66 direct pair-comparisons based on 12 different concepts, using the criterion standard (metric) of red and white as 50 "galileos" apart. The questions were asked in the following form: "If red and white are 50 galileos apart, how far apart are sheep and goats?" This process was repeated for all 66 pairs. In this manner, a 12 by 12 dissimilarity matrix was generated. This matrix was then be averaged across individuals producing a mean distance matrix which would next be converted into a multidimensional space to examine the meaning of the words presented below. The scaled concepts were:

1. Bad	5. Hog	9. Sheep
2. Myself	6. Horse	10. Attractive
3. Cow	7. Cat	11. Goat
4. Beneficial	8. Good	12. Pig-Hog-Boar-Swine

These concepts were chosen for a number of reasons. First, was the selection of a symbol which has a variety of synonyms that sufficiently varied in their frequency of occurrence in English. The concept "pig" and its equivalents, "hog", "boar", and "swine" met this criterion. According to Thorndike & Lorge (1944), "pig" occures 44 times per million words, "hog" 14 times, "boar" 11 and "swine" 8.

As evidence that these terms are infact synonyms their definitions according to Webster's New International Dictionary are presented below. Note that each definition makes reference to at least one other of the words.

boar--the uncastrated male of swine, the wild hog

hog--a domestic swine, a pig, sow or boar

pig--a young swine of either sex that has not reached sexual maturity, a swine of any age, domestic or wild

swine--any hooved mammal of the hog kind, a hog

Additionally, the words are often used interchangeably. In a recent article on pigs in National Geographic, the author used all four words equivalently to refer to the same referent. Their frequency of occurrance in the article were: "pig", 104; "hog", 22; "swine", 11; and "boar", 6; (Britt, 1978).

Second, the domain of animal names (cow, dog, horse, cat, sheep and goat) was chosen because theoretically valid results have been obtained by scaling such lexical items (Henley, 1969). Additionally, as Woelfel et al., (1978) and Woelfel and Fink (in press) have shown, the meaning of a word is dependent on the domain in which it is scaled. The "pig" concept could have been scaled in a different domain, say political terms, producing an entirely different solution. Further, one may argue that the frequencies reported by Thorndike and Lorge were primarily generated while those terms were used in the animal

domain rather than in some other context. Thus, the frequencies of occurrence estimates may have less predictive power if the synonyms were to be scaled in some other domain.

Third, a number of attributes (bad, beneficial, good and attractive) were also scaled to define the synonym. Cody (1976) has shown that the scaling of objects relative to evaluative adjectives provides theoretically important results in terms of implicit personality theory. Finally, the scaling of these concepts along with a concept of self, "myself" makes it possible to test hypothesis two.

The twelve individual concepts were placed in random order and then the pairs were ordered as specified by the Ross Matrix (Ross, 1939). The Ross Matrix optimizes the order for stimuli in the method of pair comparison. The method maximizes the distance between a stimulus and itself in the order of presentation and equalizes the number of times stimulus appears as the first or second member of the pair. In this way, the effects of order can be minimized.

Design and Subjects

Four alternative instruments were developed. They varied only in terms of which synonym was presented to the subjects. In every instance where the word "pig" was presented in one condition it was changed in the different conditions to "hog", "swine", or "boar". Subjects were randomly assigned to one of the four conditions. The questionnaire was administered in the spring of 1978 to classes of undergraduates at an eastern technological university. Administration took 30 minutes. The sample sizes for each condition were: "pig", 44; "hog", 51; "boar", 47; and "swine", 51.

RESULTS

The mean distance matrices for the four groups are presented in tables one through four. These matrices were transformed to spatial coordinates using MDS (Torgerson, 1958). The first three real dimensions of the spatial coordinates for all four groups combined are presented in figure one. These three dimensions explain 88.5% of the total (real & imaginary) variance in the overall coordinate system.[3] The displayed locus for the individual synonym was generated as follows. For each condition a set of spatial coordinates was produced. Then, each of the four spaces were rotated to congruence with the overall space using only the unmanipulated concepts. The synonym was allowed to vary, yielding the coordinate values plotted in figure one. This analytical proceedure is explained below in greater depth.

[TABLES ONE TO FOUR AND FIGURE ONE ABOUT HERE]

In order to compare the four groups, the spatial manifolds were rotated to a least square best fit congruence using all n-1 (11) dimensions (Woelfel, et al., 1975). The mean difference among the four groups was 40.83 units, indicating substantial differences among the groups. This suggests that semantic structures generated with concepts considered to be synonyms are not equivalent.

In order to determine if the variance among the groups could be systematically attributed to the synonym rather than the variance of the other concepts, the spaces were again rotated to congruence. This time only the theoretically stable concepts were included. That is, this rotation attempted to minimize the discrepancies among the concepts which were unmanipulated in the design. The "pig" concept was allowed to vary. It was not included in the rotation. The algorithm necessary to perform this analysis is described by Woelfel, et

al., (1975). A computer program which performs the necessary operations is known as Galileo (TM) IV is available at a number of academic institutions (Woelfel, et al., 1976a).

The results of these rotations are revealing. The average root mean square among the groups including the synonym was 33.95.[4] The mean calculated without the "pig" concept was only 27.59, or only 81% as large. This indicates that 19% of the overall difference among the groups can be attributed to the difference in meaning among the synonyms. The average mean difference among the four synonyms alone was 54.94 or almost twice (1.99 times) as large as the difference among the groups attributable to the unmanipulated concepts.

Worth noting are the standard deviations around the various means reported above. The standard deviation of the differences among the groups with the synonyms included was 10.81. Without the synonyms, it was only 4.11. This coefficient for the differences among the synonyms was 22.23. Clearly, as expected, the semantic structure is quite stable across the four groups when the experimental manipulation was not included in the analysis. With the synonym included, it is considerably larger, indicating that the manipulation is the major source of the instability among the groups. The differences among the groups are summarized in tables five to eight.

[TABLES FIVE TO EIGHT ABOUT HERE]

In terms of hypothesis one, all four spaces are significantly different. Thus, the expected null hypothesis of no difference among the semantic spaces can be rejected in favor of the theoretical hypothesis. The overall t for the ordinary least square rotation ($\bar{X}$ = 40.83) was 101.79 ($p<.001$). For the root mean square rotation including the synonym in the calculation of the mean but not in the rotation ($\bar{X}$ = 33.95) t = 10.41($p<.001$). And the value for the

above rotation without the synonym in the calculation of the mean ($\bar{X}$ = 27.59) was t = 22.27 ($p<.001$).

Since there are significant differences among the four groups attributable to the synonym, it is worth examining how they differ in order to determine the mechanism by which people organize their semantic structures. The most apparent way in which the synonyms' loci differ is with respect to the self. As predicted, the concept "pig" is closest to the concept myself, 133.58 units; "hog" is next, 150.37 units; with "boar" and "swine" about the same distance from the self, 171.00 and 174.38 units respectively.

Similarly, the two positive attributes scaled in the space, beneficial and attractive, show a similar pattern. With both, "pig" is the closest to the attribute, followed by "hog", "boar" and "swine". The distances for beneficial are respectively, 74.29, 92.81, 109.49 and 139.77 units. For attractive, those distances are 108.26, 157.81, 168.95 and 197.26 units. While there are other differences among the groups, they do not appear to be systematic. The reader is invited to examine tables one to four in order to discover any other systematic differences.

In terms of hypothesis two, the linear trend analysis showed that the null hypothesis can be rejected. The analysis was performed with both the rank order of the frequency of occurrence (times per million words) and the actual frequency of occurrence in English. The F-values were 31.33 and 18.00 respectively. Since direction was specified, the F-value necessary to reject the null at the .05 level with degrees of freedom 1, 2 (1, N-2) was 9.26.[4]

In the case of the positive attributes both are significantly related to distance from the self. The trend analysis revealed a F = 31.33 for beneficial ($p<.05$) and F = 13.29 ($p<.05$) for attractive.

In summary, both hypotheses find support from the data. The four semantic spaces are significantly different and the difference can in part be accounted

for by the changes in the distance from the self for the synonyms. The more frequently the lexical item is used in English, the closer the symbol is to a concept of self. Unexpectedly, similar results were found with a pair of positive attributes, beneficial and attractive. They may also contribute to the difference among the semantic structures. The implications of these findings will be discussed below.

DISCUSSION

The results of the above analysis suggest that the semantic structures individually generated from a set of synonyms are not equivalent. Despite the fact that the synonyms refer to the same referent, these structures have systematic differences in meaning rendered by the individual symbol's unique relation to other lexical items used to define that symbol. These variations seem to be behaviorally based, such that the more frequently a word is used, the closer that concept will be to a concept of self. Thus, the results lend support for a consensual behaviorally based theory of meaning (Barnett, 1976).

Of special note is the serendipitious finding that the more frequently a word is used, the closer that symbol will be to positive attributes used to define it. This result is consistent with the results discussed by Zajonc (1968). Mere exposure to a stimulus will produce a positive evaluation of that stimulus. Further, the more people are exposed to a stimulus, the more they will like it. Indeed, as Zajonc pointed out, for 154 antonym pairs chosen from Thorndike and Lorge, 68% of the positive symbols occur more frequently and they are preferred by a majority of a sample of college students. This further suggests that meaning is behaviorally governed and that the meaning of any symbol is an empirical question. It cannot be determined by a small group of wise men composing lexicographies, but must be determined by measuring the actual users of that symbol.

One obvious implication of the obtained results is that the researcher should take special care in the selection of concepts when using MDS. These concepts should come directly from the same users of the symbols that will be asked to perform the pair-comparisons. This is especially true if the reason for the research is to alter a population's attitude toward a given object. It has become standard practice in "Galileo" research to perform a series of open-ended interviews to generate the actual concepts people use to evaluate a political campaign or commercial product. The unacceptable alternative is for the researcher to impose a set of concepts on subjects to use when evaluating an object. This may result in a misleading solution and an unsuccessful message campaign, even if the choice of the symbols is only among a set of synonyms. For example, Woelfel et al., (1976b) identify a set of mathematical procedures to identify optimal message strategies from the loci of stimuli in the spatial manifold. These procedures were carried out on the four different groups in the study in order to determine the optimal persuasive message so that the "pig" term would be redefined closer to the self. Only 57.4% of the messages which would shorten the distance between these terms were common to all four groups. In this case, the differences between the conditions were only synonyms. Thus, special attention should be paid to the selection of stimuli for MDS.

There are a number of weaknesses in this research which should be pointed out. The most serious of these is the use of Thorndike and Lorge to estimate the synonyms' frequency of use in English. Published in 1944, the word counts were based on documents published prior to that date. Thus, the frequency estimates are at least 35 years out of date. Language changes over time and thus those estimates may lead to erroneous conclusions. In addition, the use of this method does not provide a measure of the frequency at which the actual

subjects use these terms. An alternative procedure would be to have subjects provide subjective estimates of their use of the words and use these measures to predict semantic structure.

Another methodological shortcoming is the exclusion of the word "sow" as an additional condition. A "sow" is "an adult female swine, a female hog of any age." This lexical item occurs less than one time per million words. Its inclusion would increase the variance in the frequency variable and this increases the confidence in the stated conclusions.

This condition becomes increasingly important when gender is considered. One of the additional attributes which differentiate these synonyms is sex. "Boar" represents the male of the species. "Sow" the female. "Pig", "hog", "swine" do not make reference to gender. This suggests that "male" and "female" should have been added to the concept list. Also, "wild" and "domestic" should have been included. The synonyms could also be differentiated by this pair of adjectives.

The results reported here suggest some future research. This report is only part of an ongoing study to test some of the theoretical ideas of Woelfel and Saltiel (1975). They suggest the attitude change is inversely related to the inertial mass of the concept being altered. Inertial mass may be taken to be the information history of the concept. Frequency of occurrence may provide a reasonable estimate of a concept's mass. Thus, it is expected that if the same persuasive message were presented to the same four groups and then a post-test measure made that "pig" would be the most stable, then, "hog", "boar", with "swine" having the greatest attitude change. The second half of this study is planned to test these ideas. With the results from the message generation procedures (Woelfel et al., 1976) a persuasive message has been written. It

says that "pigs", "hogs, boars, swine [sow]) are "beneficial" and "attractive". This message maximized the predicted motion toward the target concept, "myself", for each of the individual groups and the four groups combined. A separate group post-test design will take place and the results compared with the ones reported here and the appropriate control groups. In this way, it will be possible to determine the utility of frequency of occurrence in English as an indicator of inertial mass and further insights into the Woelfel-Saltiel theory may be gained. Finally, a fifth condition, "sow", will be included in the post-test along with the subjects' subjective estimates of their frequency of use of these five synonyms.

In summary, this paper has investigated the nature of synonyms and found that they are not equivalent in meaning (semantic structure) despite referring to the same referent. Systematic distortion from equivalence occurs due to variance in the use of the terms and in their relation to positive attributes. These results were next discussed in terms of a behaviorally based theory of meaning. Finally, future research ideas based on the reported findings have been discussed.

NOTES

1. This paper assumes a strict definition of synonym, i.e., words which express identical or equivalent meaning and may be equally well interchanged. They may be defined wholly, or almost wholly, in the same terms. Historically, there has been considerable debate over the definition of the term synonym. For a complete historical review and statement of the current status on the issue of synonyms see the introduction of Webster's New Dictionary of Synonyms, Philip B. Grove, editor (1973).

2. The use of significance tests and inferential statistics of any sort runs against the spirit of metric MDS. Metric MDS is a series of continuous ratio scaled distance estimates. It assumes the height of absurdity to reduce these estimates to a dichotomous decision of an acceptance or rejection of the null hypothesis. These data can and should be used as a description of the semantic structure of individuals or groups. Thus, one could say they describe a certain relationship without attempting to infer beyond the sample of subjects or concepts. Additionally, these data are based on a large number of independent observations of the relationship between a particular pair of concepts. This notion is not taken into account by this significance test, where the unit of analysis is the number of concepts or spaces and thus the degrees of freedom are some small numbers rather than the number of independent observations.

3. Imaginary variance results because the multidimensional spaces are non-Euclidean. That is, the mean distance matrices are non-positive semi-definite. This problem is explained further in note three and by Woelfel et al. (1978).

4. Root mean squares were calculated rather than ordinary means because some of the difference between the groups could be attributable to differences on the imaginary dimensions. The imaginary dimensions result because the semantic structures are non-Euclidean. In this case, the mean proportion of variance on the imaginary dimensions was 25.8. Non-Euclideanisms result in semantic space because the meanings are incongruent and great distances in space between semantic domains are not adequately described by a linear metric. For a more complete discussion see Woelfel, et al. (1978).

5. The individual t-tests find only one of the differences significant at the .05 level (Pig-Swine) and one (Pig-Boar) significant at the .10 level, although all are in the predicted direction and the overall trend is significant. The individual differences and values of t for the means among the synonyms are presented in the matrix below.

	Pig	Hog	Boar	Swine
Pig	0.0			
Hog	16.8/.69	0.0		
Boar	37.4/1.59	23.6/.98	0.0	
Swine	40.4/1.69	20.6/.82	3/.13	0.0

TABLE ONE

--GALILEO MEANS MATRIX--SWINE

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0											
2	156.84	0.0										
3	145.52	135.00	0.0									
4	180.58	57.20	82.78	0.0								
5	112.18	103.42	96.07	61.70	0.0							
6	115.42	103.75	57.48	78.56	73.66	0.0						
7	104.64	73.71	112.39	131.58	124.48	93.02	0.0					
8	147.36	58.77	68.78	25.72	87.08	74.81	154.31	0.0				
9	137.14	140.72	69.83	84.27	87.87	70.68	80.88	114.82	0.0			
10	141.36	53.14	151.42	66.39	127.71	96.90	96.55	63.47	138.61	0.0		
11	124.78	145.75	80.44	134.75	87.05	64.80	145.00	147.49	57.12	137.42	0.0	
12	141.66	174.38	57.30	139.76	86.08	85.22	114.31	81.15	70.88	197.26	77.35	0.0

TABLE TWO

--GALILEO MEANS MATRIX--BOAR

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0											
2	158.39	0.0										
3	132.32	149.46	0.0									
4	180.25	43.00	79.18	0.0								
5	114.95	161.53	82.91	94.88	0.0							
6	105.52	150.58	65.04	75.81	104.44	0.0						
7	98.40	157.31	134.77	113.00	71.84	102.40	0.0					
8	179.22	35.04	90.06	28.24	85.40	105.04	96.80	0.0				
9	141.97	136.56	70.33	72.11	83.04	70.76	81.77	69.77	0.0			
10	169.07	45.84	131.07	50.78	80.66	83.36	75.34	48.97	111.83	0.0		
11	104.20	167.63	74.24	93.36	67.17	70.97	101.34	95.77	48.88	153.95	0.0	
12	110.40	171.00	75.51	109.48	74.09	89.88	122.60	84.47	115.20	168.95	82.64	0.0

TABLE THREE

--GALILEO MEANS MATRIX--HOG

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0											
2	149.67	0.0										
3	151.98	121.53	0.0									
4	127.76	81.08	67.66	0.0								
5	120.79	134.65	73.36	90.10	0.0							
6	140.97	110.19	76.91	99.59	81.89	0.0						
7	108.87	140.13	98.39	139.35	94.95	116.44	0.0					
8	142.55	49.38	98.12	31.77	80.41	94.95	119.83	0.0				
9	127.82	146.34	59.72	94.06	79.25	69.84	84.30	89.97	0.0			
10	132.15	52.83	127.65	59.62	103.67	92.14	103.53	68.02	105.85	0.0		
11	121.06	167.52	83.20	108.36	69.79	81.35	93.46	107.37	59.35	117.72	0.0	
12	134.33	150.37	76.17	92.80	74.20	80.83	98.33	69.84	78.22	158.95	75.87	0.0

TABLE FOUR

--GALILEO MEANS MATRIX--

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.0											
2	120.34	0.0										
3	112.23	111.66	0.0									
4	175.34	46.02	77.18	0.0								
5	132.30	129.05	99.11	83.83	0.0							
6	135.81	150.17	59.07	67.07	90.72	0.0						
7	91.97	132.23	142.41	94.17	79.02	120.68	0.0					
8	184.81	31.48	96.30	31.47	73.69	70.73	69.20	0.0				
9	97.15	134.10	76.43	75.27	127.95	74.27	90.04	88.50	0.0			
10	167.64	38.36	113.61	69.58	76.85	85.39	62.07	64.95	85.50	0.0		
11	115.70	153.25	78.72	113.97	85.54	69.73	134.02	87.60	68.44	94.70	0.0	
12	114.64	133.58	54.83	74.29	94.21	93.88	114.23	82.83	87.77	108.25	60.06	0.0

TABLE FIVE

ROOT MEAN SQUARE DIFFERENCE AMONG FOUR GROUP

WITH SYNONYM*

	1	2	3	4
1	0.0	34.27	31.28	39.96
2	34.16	0.0	28.52	35.80
3	31.31	28.43	0.0	35.08
4	39.92	33.27	35.26	0.0

MEAN ROOT MEAN SQUARE	33.95
STANDARD DEVIATION	10.81

* Rotation did not include synonym

TABLE SIX

ROOT MEAN SQUARE DIFFERENCE AMOUNG FOUR GROUPS

WITHOUT SYNONYM

	1	2	3	4
1	0.0	28.42	30.69	35.48
2	28.57	0.0	25.52	23.78
3	30.74	25.45	0.0	28.47
4	18.54	25.17	30.27	0.0

MEAN ROOT MEAN SQUARE 27.59

STANDARD DEVIATION 4.11

TABLE SEVEN

DIFFERENCES AMONG THE FOUR SYNONYMS

	SWINE	BOAR	HOG	PIG
SWINE	0.0	66.36	20.98	64.06
BOAR	64.85	0.0	44.16	78.62
HOG	15.85	21.22	0.0	70.97
PIG	62.75	77.84	71.63	0.0

MEAN DIFFERENCE 54.94

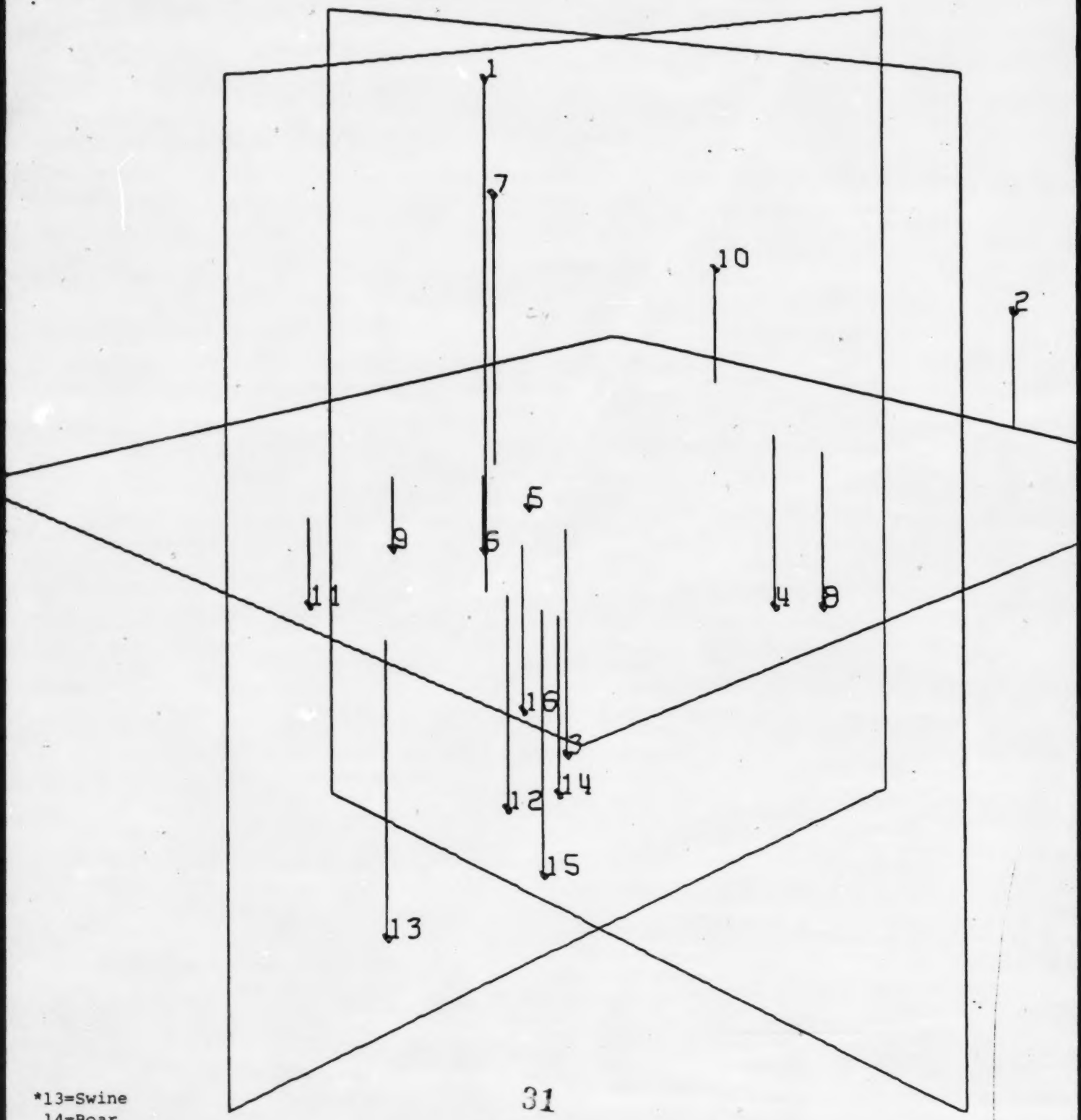
STANDARD DEVIATION 22.23

TABLE EIGHT

SUMMARY OF MEAN DIFFERENCES AND STANDARD DEVIATIONS

	$\bar{X}$	σ
LEAST SQUARE ROTATION	40.83	1.33
ROOT MEAN SQUARE WITH SYNONYM	33.95	10.81
ROOT MEAN SQUARE WITHOUT SYNONYM	27.59	4.11
FOUR SYNONYMS	54.95	22.23

FIGURE 1
Three-Dimensional Space For All
Four Groups Combined With
Individual Synonyms*



*13=Swine
14=Boar
15=Hog
16=Pig

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